DTA Demand Calibration Methodology

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Overview

- Demand Adjustment in General
- DTA Model Demand Calibration
- Details of Methodology
- Results from Applied Methodology
- Issues with the Methodology
- Possible Extensions
- Possible Additional Applications
- Summary

Demand Adjustment in General

- General principle:
  - Determine demand such that when assigned, flows replicate observed counts
- Static demand adjustment
  - Static assignment models
  - Usually for error checking, not calibration
- Important for DTA models
  - Static demand may result in flows > capacity
    - Simulation based DTA may not be able to simulate
  - Use to determine departure time profile
    - Static demand not often segmented by detailed departure periods

Demand Adjustment, Typical Uses

- Operational Planning Studies
  - Recently observed counts
  - Demand from Planning Demand Models
  - Primary interest is traffic response to operational changes
- DTA Model with Future Year Demand
  - Less common
  - Problematic – how do you apply adjustments in future???

Demand Calibration for DTA Models

- Common Approach:
  - Divide Planning Demand into short periods
    - Start with one 3 hour matrix -> twelve 15 minute matrices
  - Use successive static trip assignments of 15 minute matrices
  - Compare usually hourly flows and counts
  - Rough approximation
    - All trips in 15 minute period do not end in that same period
  - Further manipulation to demand tables
    - manually for remaining large discrepancies

A Different Methodology

- Divide demand matrices in 15 minute periods
  1. Solve the DTA model
     - Solve without signals if concerned about demand
  2. Weight vehicle trajectories in order to match observed counts
  3. Aggregate weighted vehicles into new demand matrices
  4. If meets convergence criteria, Stop.
  5. Repeat, starting at 1.

Details of Methodology

- DTA Model Requirements
  - Simulation-based, Dynamic Equilibrium DTA
    - Need individual vehicle trajectories
      - paths and travel times
    - Need a convergent assignment procedure
      - avoid oscillating solutions
- DTA software must write trajectories to a file
  - Format:
    - Vehicle id , (link id, arrival time)$_1$, (link id, arrival time)$_2$, etc…
- Observed Link Counts
  - 15 minute counts

Methodology Continued

- Create a table
  - rows are vehicle records
    - every vehicle simulated is in the table
  - Columns are links with 15 minute counts
    - every observed count is represented by a column
  - Cell values are:
    - 1 if the vehicle arrives at a link during the 15 minute interval represented by the column
    - 0 otherwise
  - Summing all the rows for any one column gives total assigned flow on the link during the time interval

Simple Example

Vehicle Path/Flow Incidence Table

vehicle path	factor	link #1	link #2	link #3
1	1	1	0	0
2	1	0	0	1
3	1	1	1	0
4	1	0	0	1
5	1	0	0	1
Modeled Flow		2	1	3
Observed Count		4	1	1

1st Iteration Factoring

1st Constraint Factoring

vehicle path	factor	link #1	link #2	link #3
1	2	2.0000	0.0000	0.0000
2	1	0.0000	0.0000	1.0000
3	2	2.0000	2.0000	0.0000
4	1	0.0000	0.0000	1.0000
5	1	0.0000	0.0000	1.0000
Modeled Flow		4.0000	2.0000	3.0000
Observed Count		4	1	1

2nd Constraint Factoring

vehicle path	factor	link #1	link #2	link #3
1	2	2.0000	0.0000	0.0000
2	1	0.0000	0.0000	1.0000
3	1	1.0000	1.0000	0.0000
4	1	0.0000	0.0000	1.0000
5	1	0.0000	0.0000	1.0000
Modeled Flow		3.0000	1.0000	3.0000
Observed Count		4	1	1

3rd Constraint Factoring

vehicle path	factor	link #1	link #2	link #3
1	2.0000	2	0	0.0000
2	0.3333	0	0	0.3333
3	1.0000	1	1	0.0000
4	0.3333	0	0	0.3333
5	0.3333	0	0	0.3333
Modeled Flow		3.0000	1.0000	1.0000
Observed Count		4	1	1

2nd Iteration Factoring

1st Constraint Factoring

vehicle path	factor	link #1	link #2	link #3
1	2.6667	2.6667	0.0000	0.0000
2	0.3333	0.0000	0.0000	0.3333
3	1.3333	1.3333	1.3333	0.0000
4	0.3333	0.0000	0.0000	0.3333
5	0.3333	0.0000	0.0000	0.3333
Modeled Flow		4.0000	1.3333	1.0000
Observed Count		4	1	1

2nd Constraint Factoring

vehicle path	factor	link #1	link #2	link #3
1	2.6667	2.6667	0.0000	0.0000
2	0.3333	0.0000	0.0000	0.3333
3	1.0000	1.0000	1.0000	0.0000
4	0.3333	0.0000	0.0000	0.3333
5	0.3333	0.0000	0.0000	0.3333
Modeled Flow		3.6667	1.0000	1.0000
Observed Count		4	1	1

3rd Constraint Factoring

vehicle path	factor	link #1	link #2	link #3
1	2.6667	2.6667	0.0000	0.0000
2	0.3333	0.0000	0.0000	0.3333
3	1.0000	1.0000	1.0000	0.0000
4	0.3333	0.0000	0.0000	0.3333
5	0.3333	0.0000	0.0000	0.3333
Modeled Flow		3.6667	1.0000	1.0000
Observed Count		4	1	1

Link Factored Flow for Additional Iterations

Iteration	link #1	link #2	link #3
1	3.9091	1.0000	1.0000
2	3.9767	1.0000	1.0000
3	3.9942	0.0000	0.0000
4	3.9985	0.0000	0.0000
5	3.9996	0.0000	0.0000
6	3.9999	1.0000	1.0000
7	4.0000	1.0000	1.0000
Observed Count	4	1	1

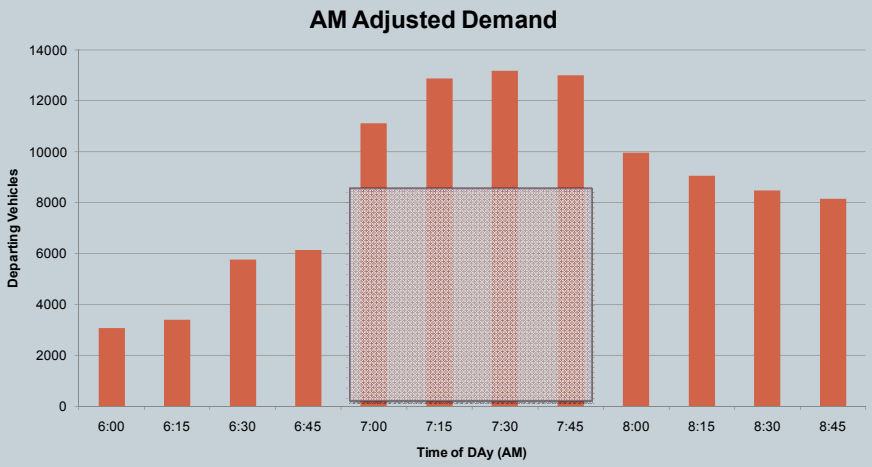
Final Vehicle Weights

vehicle path	factor
1	3.0000
2	0.3333
3	1.0000
4	0.3333
5	0.3333

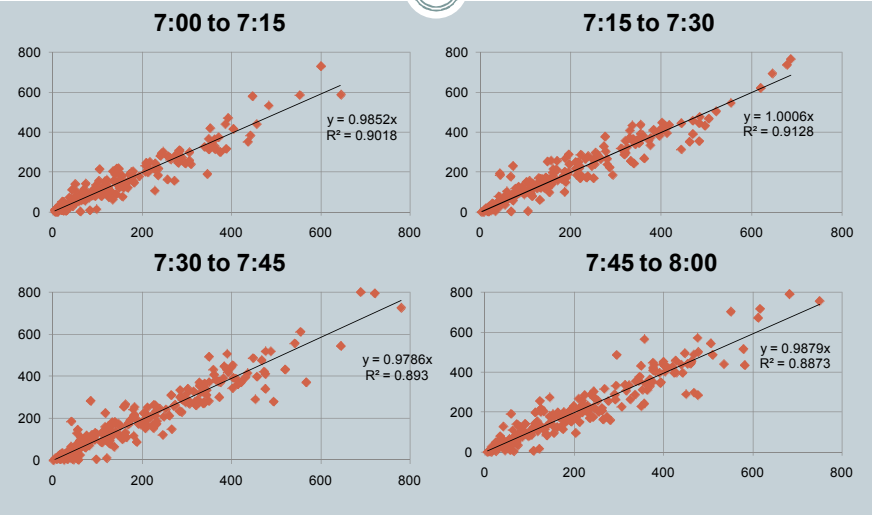
Summary of Example

- Factors calculated by IPF procedure
  - Entropy maximizing solution
- Factors used as weights when aggregating demand tables
  - Aggregate by Origin, Destination, Departure Period
- DTA re-solved with adjusted demand
  - Include signal data if it was not included before
- Iterate DTA solutions with IPF adjustments until stabilized
- Results…

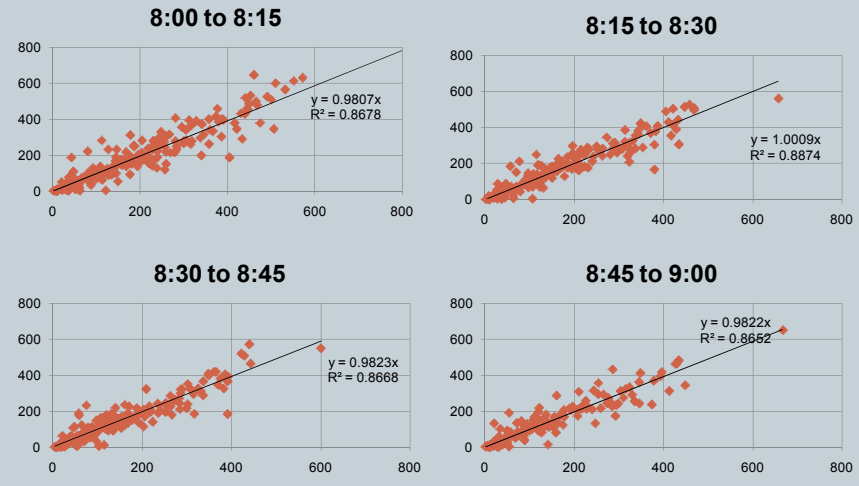
Demand for DTA Model



DTA Flow vs 15 Minute Period Counts



Guam Flow vs Count by 15 Minute Period



Implementation of Methodology

- Easy to Implement
  - Run DTA
  - Read counts, read trajectories, create table, apply balancing
  - Summarize demand, run DTA, repeat
- For DTA Results Shown:
  - ~100,000 vehicles
  - ~150 links with counts
  - IPF procedure computed in seconds
  - Runtime determined by frequency of DTA runs

Issues with Methodology

- Dependent on good observed count data
  - We initially experienced counts that would not converge
    - Flows would not equal counts
    - Indicates *possible* count errors
  - Dropping counts allowed procedure to completely converge
  - Large sample of counts recommended
    - Good coverage spatially and temporally
    - Several observations of a link and time period
    - Observations by vehicle class
- Factoring bias for short paths
  - May require more constraints than just counts

Possible Extensions to Methodology

- More diverse constraints
  - Turning movement counts
    - Columns represent link pairs
    - Incidence table has a 1 if vehicle trajectory crosses link pair in observed time period
  - Mixed constraints
    - Variable time period counts
      - May not always have 15 minute counts – mix in hourly counts
    - Link counts and turning movement counts

More Extensions to Methodology

- Demand based constraints
  - Trip length profile
    - Columns represent vehicle paths in 0-5, 5-10, etc. miles
  - Trip departure profile
    - Columns represent vehicle paths departing in time intervals
  - Area to Area profile
    - Columns represent vehicle originating and destined to area pairs
      - CBD, urban, suburban, areas defined by rivers
- Target values reflect observed (HIS) demand profiles
- Trip length constraint would have helped with our short path bias

Other Applications?

- Suggestions for further study…
- Use factors from demand oriented constraints to identify demand model shortcomings
  - Trip length, departure time, area to area, others?
  - Large factors identify problems with model and/or data
    - Focus attention to specific parts of demand models
      - Trips > 20 miles destined to CBD
    - Refinements to demand models may reduce values of IPF factors
      - Better demand model -> fewer adjustments necessary
- Forecast with improved base year demand model which better replicates counts when assigned

Even More Applications?

- Activity Based Demand Model Interaction with DTA
  - Vehicles are associated with person activities
  - Vehicles characterized by many more attributes
  - Many activity based interactions can be defined as constraints
    - Many possible feedback points between AB Models and DTA
      - After long term choices
        - Usual work and school locations
        - Auto ownership
      - After short term choices
        - Activity generation
        - Trip related choices

Summary and Conclusions

- IPF Based demand calibration successful for us
- Look at expanding constraints
  - Turning movement counts
  - Demand oriented constraints
- Need to explore possibility of calibrating demand models
- Comments, suggestions:
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